404387

CATALCETO TO POSTIVAS AU TOSTIVAS AU TOSTI

# A SURVEY OF GEOMAGNETIC MICROPULSATION RESEARCH

CONDUCTED IN CONNECTION WITH THE CO-OPERATIVE GEOMAGNETIC MICROPULSATION

MEASUREMENT PROGRAM

Report No. 130

15 May 1963

Compiled by

H. W. Smith

Electrical Engineering Research Laboratory
The University of Texas

under

MAY 2 0 1963

Contract Nonr 375(14) NR 371-032

OFFICE OF NAVAL RESEARCH Washington, D. C.

404 387

The research in this document has been made possible through the support and sponsorship extended by the Office of Naval Research under Contract Nonr 375(14). It is published for technical information only and does not necessarily represent recommendations or conclusions of the sponsoring agency.

Reproduction of this document in whole or in part is prohibited except with the permission of the office of origin. However, ASTIA is authorized to reproduce the document for "U.S. Governmental Purposes."

Requests for additional copies by Agencies of the Department of Defense, their contractors, and other Governmen Agencies should be directed to

ASTIA
Documents Service Center
Arlington Hall Station
Arlington 12, Virginia

Department of Defense contractos must be established for ASTIA services or have their "need-to-know" certified by the cognizant military agency of their project or contract.

All other persons or organizations should apply to the

U.S. Department of Commerce Office of Technical Services Washington 25, D. C.

# A SURVEY OF GEOMAGNETIC MICROPULSATION RESEARCH CONDUCTED IN CONNECTION WITH THE CO-OPERATIVE GEOMAGNETIC MICROPULSATION MEASUREMENT PROGRAM

Report No. 130

15 May 1963

Compiled by

H. W. Smith

Electrical Engineering Research Laboratory

The University of Texas

under

Contract Nonr 375(14) NR 371-032

OFFICE OF NAVAL RESEARCH

Washington, D. C.

# TABLE OF CONTENTS

		Page
	ABSTRACT	iii
I.	INTRODUCTION	1
II.	SURVEY RETURNS	2
III.	SURVEY RESULTS	3
	APPENDIX A	A-1
	APPENDIX B	B-1

### **ABSTRACT**

At a conference on geomagnetic micropulsations held at the University of California on August 12-14, 1962 a committee was formed from representatives of the several research groups in attendance to conduct a survey to determine the desirability of a co-operative measurement program. The favorable response from this survey resulted in the formation of the Co-Operative Geomagnetic Micropulsation Measurement Program. This report contains a condensed summary of a survey form mailed to all research groups in the United States and Canada known to have an interest in geomagnetic micropulsations.

### I. INTRODUCTION

In the years following the IGY there has been a very rapid increase in both interest and research activity in geomagnetic micropulsations and related phenomena. Although no concise definition of the term micropulsatis generally recognized, most investigators will agree that the frequency range from about 0.001 to 5.0 cps includes most of the signals of interest. In this frequency range there is, thus, some overlap between the micropulsation measurements and the normal and rapid-run magnetograms that have been well standardized and widely recorded by geomagnetic observatories for many years.

Within the past few years a number of investigators have voiced a growing need for a more complete geographical coverage of micropulsation and earth current measurements, as well as a desire for suitable standards for equipment, bandwidths, and calibration procedures. For these reasons a number of research activities represented at a conference on Geomagnetic Micropulsations held at the University of California on August 12-14, 1962 decided to take positive steps toward a co-operative program designed to help satisfy some of these needs.

As a first step, a co-ordinating committee for what has become known as the Co-operative Geomagnetic Micropulsation Measurement Program (CGMMP) was selected. This committee was initially charged with the task of conducting a survey to determine the interest and willingness of research

activities to participate in such a program. If the survey showed an insufficient interest on the part of the research groups, the whole program would be abandoned without further effort. It was decided that a favorable response would warrant the establishment by this committee of recording schedules, the gathering and distribution of selected data, the study of equipment and standards, and a variety of other activities associated with the program.

Members of this co-ordinating committee are as follows:

- H. W. Smith The University of Texas Chairman
- A. K. Harris S.R.D.L. Fort Monmouth
- J. R. Heirtzler Lamont Geological Observatory
- V. P. Hessler Geophysical Institute University of Alaska
- S. H. Ward University of California

It is the purpose of this brief report to summarize the results of a survey form mailed to all research groups in the United States and Canada known to have an interest in geomagnetic micropulsation phenomena.

### II. SURVEY RETURNS

A copy of the original survey form is shown in Appendix A. In addition to questions relating to equipment, test sites, timing, etc., entries were requested regarding special interest, data processing facilities, willingness to participate in a joint measurement program, and comments and suggestions.

From these original returns a condensed form, mostly relating to equipment and measurements, was compiled. These condensed forms are

shown in Appendix B. A total of 30 research groups listing approximately 60 fixed or mobile sites are included in this summary. In addition a number of investigators involved in theoretical studies or in related fields expressed a desire to receive copies of data and results obtained from the program.

### III. SURVEY RESULTS

A study of the original returns and accompanying letters, publications, and reports provides the basis for the following observations and conclusions:

- 1. Perhaps the most significant result of the survey is the fact that an overwhelming majority of the replies were in favor of the program and promised co-operation in varying degrees ranging from 100% to occasional participation if it did not interfere with other commitments. The most frequent reply was to the effect that co-operation would be to the fullest extent that facilities and prior commitments would permit.
- 2. The survey revealed, as expected, a wide diversity in equipment and recording techniques. There is no question but that this diversity constitutes a major difficulty in the exchange of data. A subcommittee is currently studying this problem, but since so much of the equipment is already in existence, attempts to standardize in the early stages of the program will have to be on a minor scale. This problem is really international in scope and is currently under study by Committee No. 10 of IAGA. It was mentioned more than anything else in the comments and suggestions entry on the survey.

- 3. Partly as a consequence of the equipment and operating diversity mentioned in item 2, the original survey form was not entirely appropriate as is often the case. Thus, the amount of detail in the descriptions of equipment and recording techniques varied from meager to most elaborate, requiring numerous footnotes and explanations. Some caution is, therefore, appropriate in using the condensed forms as they were difficult to compile, and there are no doubt important omissions and inaccuracies.

  Questions on specific details should be directed to the individual investigators.
- 4. No claim is made that this survey represents all of the research currently being conducted in this area. On the contrary, the committee is well aware of highly significant programs operated by other groups and individuals. In general, these programs have specific experiments in progress and the data are not generally available to a group as large as the CGMMP. Notable in this regard are the networks of stations operated by Benioff, Campbell, Maple and others.
- 5. It should not be expected that every research group will participate in every simultaneous recording period, Hopefully, a reasonable percentage will be in operation on any given test.
- 6. The geographic distribution of stations is evident in the condensed forms, but may be summarized as follows: The largest concentration of stations is in the U.S.-northeast-Canadian-southeast, or along the 70th meridian. There is a secondary grouping along the west coast of North America. Some coverage in the Pacific, Puerto Rico, New Zealand

and Japan is anticipated. Certain European stations, particularly the French who also operate in South Africa, have expressed a willingness to co-operate on specific occasions. Notable gaps exist in the lower latitudes and in the mid-continent area. As mentioned in item 5, however, the actual coverage may vary considerably. In any event the network is potentially larger than any yet attempted.

## APPENDIX A

Geomagnetic Micropulsation Survey Form

## GEOMAGNETIC MICROPULSATION SURVEY

# I. Signal Components Normally Recorded: (Use code below)

	Code
H <sub>t</sub>	Total Magnetic
H	North Magnetic
H	East Magnetic
Hz	Vertical Magnetic
Ex	North Electric
E	East Electric
Ez	Vertical Electric
Other	Please specify

Signal Component	Bandwidths	Basic Instrument (Magnetometer, coils, etc.)	Normal Full Scale Sensitivity	Approx. % of time recording
,				

### II. Recording Sites:

Site	Signals Recorded	Status - past, present, future
·		

### III. Recording Equipment:

(Please describe briefly the type of recording equipment available including normal chart or tape speeds)

## IV. Primary Interest or Specialization:

(Briefly indicate any special interest in the field of micropulsations, i.e., magnetotellurics, pearls, Schumann resonances, etc.)

V. Timing:
(Please describe basic timing device with an estimate of timing accuracy)
VI. Computing and Data Processing Facilities:
(Please describe briefly, including data processing facilities)
VII. Background Noise Level:
(Please describe any unusual noise problems at measuring sites)
VIII. Please indicate the extent you would be willing to cooperate in a joint measurement program at selected times.
IX. To what extent would you be able or willing to make available copie of selected data to others in a joint measurement program?
X. Equipment
(Please reference reports or publications which describe your equipment. If you have a brief equipment write-up, please

XI. Comments and Suggestions:

include a copy.)

APPENDIX B

Special Interests:	
Reported by: Elwood Maple	
Research Group: Ionospheric Physics Lab. GRD - AFCRL Bedford, Mass.	

Recording Site	Signal Component	Basic Instrument	Bandwidth	Full Scale Sensitivity	Timing Accuracy	Recording Status and % Time
Strawberry Hill, Mass.	H <sup>X</sup> H	Coils	0.005-4 cps	Variable "	1 sec. or better	Continuous for selected intervals of several days
	Ha H	<b>= =</b>	<b>.</b>	n Reserve-low		or more each - since June 1962.
	Ή,	Ξ	Ξ.	sensitivity channels	=	=
	Ħ×	Coil	1-50 cps	variable	=	=
Pt. Barrow, Alaska*						To start operation in 1963.
W Defende						

# Motes and References:

<sup>\*</sup> Equipment similar to Strawberry Hill to be furnished by AFCRL. Station to be operated by Dr. V. P. Hessler, Univ. of Alaska.

Recording on 7-channel, 1/2 in. tape, 0.1 or 0.05 ips. Also visual playback.

Research Group: Geophysical Institute University of Alaska College, Alaska	2: rtitute laska a	Reported By: V. P. Hessler	H	Special Interests Broad coverage o micropulsation pl	of high latiti phenomenon,	Special Interests: Broad coverage of high latitude earth current and micropulsation phenomenon, conjugate points, etc.
Recording Site	Signal Component	Basic Instrument	Bandwidth	Full Scale Sensitivity	Timing Accuracy	Recording Status and % Time
College	a a v	Earth probes potentiometer EA	dc-0.2 cps	1000 mv/km	6"/hr.*	100% since Oct. 1956
Barrow	я,	Earth probes- potentiometer- EA	dc-0.2 cps	500 mv/km	6"/hr.*	
Conjugate. Point- Alaska- Canada New Zealand, etc.	ल <sub>×</sub> ल <sub>&gt;</sub>	Earth probes- potentiometer- EA	dc-0.2 cps dc-0.2 cps		6"/hr.*	See Final Report, Geophysical Institute AF 19(604)-3075
College	ы Х	Earth probes- potentiometer- EA cycle counter	dc-1 cps	5 mv/km		. 100% since 1958
Notes and References:  Continued on next page  Chart:speeds  Numerous reports of C	rences: lext page oorts of Geophy	otes and References: Continued on next page Chart.speeds Numerous reports of Geophysical Institute under Contract AF 19(604)3075.	er Contract	AF 19(604)3075		

•

•

Research Group:	:dn	Reported by:	<u>ତ</u> ା	Special Interests:	i.:	
Geophysical Institute University of Alaska College, Alaska (continued)	nstitute Alaska ka	V. P. Hessler		(Listed on preceeding page)	eding page)	•
Recording Site	Signal Component	Basic Instrument	Bandwidth	Full Scale Sensitivity	Timing Accuracy	Recording Status and % Time
College	ਜ਼ ×	Earth probes- potentiometer- EA micropulsation recorder	.0533 cps	400 mv/km	3"/hr,*	100% since Nov. i962
College	면×	Earth probes- potentiometer-	. I-1 cps	125 mc/km	3/4" * min	100% since Nov. 1961
	ल <sub>×</sub>	micropulsation recorder and special trace on loop of chart paper	5-20 cps		30" * min	Under development
College	<b>д</b> д	Rb. vapor magnetometer Helium vapor magnetometer	variable	variable		Under development
Barrow	H H Y Z	Coil systems and tape recording	.01-3 cps	2 channels on each 80 db range		100% will go into operation about March 1,
Notes and References:	erences:			·		

\* Chart speeds

•

Research Group: University of Alberta Edmonton, Alberta, Canada	u <u>p:</u> Alberta berta, Canada	Reported by: K. Vozoff	off	Special Interests: Magnetotellurics	urics and pule	Special Interests: Magnetotellurics and pulsation structure
Recording Site	Signal Component	Basic Instrument	Bandwidth	Full Scale Sensitivity	Timing Accuracy	Recording Status and % Time
Leduc, Alberta, Canada	HXHY HZ AXA	Iron Core Coils Copper rod electrode	2 millicps- " 10 cps " 2 millicps- " 8 cps	0.01-10γ " " 1mv/km "	±50 milli- sec	<b>8</b> €
Notes and References:	erences:					•

•

•

-

Research Group: Institute of Earth Sciences The University of British Columbia Vancouver 8, Canada	: h Sciences of British anada	Reported by: J. A. Jacobs	·	Special Interests:  Micropulsation in the frequency range 0.2-10 cps-(pearls).	in the frequentiaris).	ncy range
Recording Site	Signal Component	Basic Instrument	Bandwidth	Full Scale Sensitivity	Timing	Recording Status and % Time
Westham, island approx. 20 miles south of Vancouver	EXET EXES	Iron core coils	0.01-5cps and 0.3-3cps 0.01-5cps	אאל אל מימים היים	l sec	H, H 80% H 20% At present 0%

# Notes and References:

- English, W. N., D. J. Evans, J. E. Lakken, J. A. Shand and C. S. Wright, Equipment for observation of the natural electromagnetic background in the frequency range 0.01-30 cps., Pacific Naval Laboratory reprint 61-3.
  - Shand, J. A., Proceedings of the meeting to discuss the cooperative low frequency electromagnetic measurement program of 1960, Pacific Naval Laboratory Note 60-42. Appendices C and D. 7

Research Group: Department of Mineral University of California Berkeley, California	ineral iforni rnia	Technology S. H	S. H. Ward	Special Interests: Tellurics - Struct Dynamics of the M	Special Interests: Tellurics - Structural studies Dynamics of the Magnetosphere	ies phere
Recording Site	Signal Component	Basic Instrument	Bandwidth	Full Scale Sensitivity	Timing Accuracy	Recording Status and % Time
Briones Valley, California	H <sub>t</sub> H <sub>hor</sub>	R <sub>b</sub> magnetometer', 0001-1 cps	, 0001-1 cps	γ2	11 sec	25%
Sacramento, California	H,H, O,H,	R magnetometer 0.001-1cps	0.001-1cps	2,4  10 mv		25%
Notes and References:	ences:					and the second s
Report in Process	So on					

.

sations with Frequency drifts	Recording Status and % Time	Continuous Set experiments
1 7	Recor	Set 6
n of micropu ow 0.5 cps. 5 - 2 cps.	Timing Accuracy	. I se c
Special Interests: Annual variation of micropulsations with frequencies below 0.5 cps. Frequency d in the range 0.5 - 2 cps.	Full Scale Sensitivity	3y at 0.05 cps 0.004y
.χ.	Bandwidth	0.01-0.5 cps
Reported by: C. Ellyett	Basic Instrument	ground loop
Research, Group: University of Canterbury P. O. B. 1471 Christchurch, New Zealand	Signal Component	H Z Z
Research, Group: University of Canterbury P. O. B. 1471 Christchurch, New Zeala	Recording Site	Department field station at Rolleston 15 mi. from Christchurch 172°24'20" E-43°37'10" S

Research Group: Research Department General Dynamics/Elect	Research Group: Research Department General Dynamics/Electronics	Reported by: Raymond A.	by: A. Santirocco		at sea from 0.01-1 cps ng signal sources and p	Special Interests: $ \begin{array}{ccccccccccccccccccccccccccccccccccc$
Rochester, N.Y.	. Y.			phenomena.		
Recording Site	Signal Component	Basic Instrument	Bandwidth	Full Scale Sensitivity	Timing Accuracy	Recording Status and % Time
Hathawav Hill.	H <sup>×</sup> H	Mumetal coils	e001-3 cps	$2 \times 10^{-2} \text{y/sec}$	Slow speed \$10 - 15 sec	
Penfield, N. Y.	, H			:	Tape records ‡(1-10)millir sec	8° .
Beneway Farm Ontario, N. Y.	щ×	Aircore loop	20-15,000 cps			
					ľ	
Notes and References:	ferences:					
A report will	A report will be issued shortly.	٠				•

b

Special Interests:  Correlation of geomagnetic micropulsations with VLF phase perturbations during periods of high micropulsation activity and magnetic storms. Spectrograms of geomagnetic and VLF phase fluctuation.	Recording Status and % Time	100%	
rests: of geomagnerase perturbing micropulorms. Spect	Timing Accuracy	fraction of 1 sec	
Special Interests:  Correlation of geory with VLF phase periods of high minagnetic storms.  magnetic and VLF	Full Scale Sensitivity	100 y at 0.001 cps 1 y at 5 cps 70 y at 5 cps	
Reported by: C. F. Sechrist, Jr.	Bandwidth	0.001-5 cps	
Reported by: C. F. Sechr	Basic Instrument	Iron core coil	
up: Inc. artment Pa.	Signal Component	π×	ess:
Research Group: HRB-Singer, Inc. Research Department State College, Pa.	Recording Site	State College, Pennsylvania 49°49'N 77°53'W geographic coordinates	Notes and References: Report in process

with known ch as SC,	Recording Status and % Time	100% since Jan: 1962	
Special Interests: Micropulsations associated with known geomagnetic phenomena, such as SC, SI, bay, flare, P <sub>c</sub> and so on.	Timing Accuracy	synchronance clock driven from power line, checked once every 24 hours with WWV	
Special Interests: Micropulsations a geomagnetic phen SI, bay, flare, Pc	Full Scale Sensitivity	6.6 y per 100 divisions approx. 0.060 y	
ed by: sushita	Bandwidth	to 1 cps	
Reported by: S. Matsushita	Basic Instrument	R <sub>b</sub> Vapor magnetometer	
<u>ıp:</u> Observatory rado	Signal Component	Ħ	o problem."
Research Group: High Altitude Observatory Boulder, Colorado	Recording Site	High Altitude Observatory Radio Astronomy Laboratory 3 miles north of Boulder.	Notes and References: Noise level ''no problem.''

Research Group: Hughes Aircraft Co. Communications Division Los Angeles 9, Calif.	up: .ft Co. ns Division , Calif.	Reported by:  S. W. Lichtman	b <u>y:</u> htman	Special Interests: Magnetotellurics detection and com	sts: ics directed communicati	Special Interests: Magnetotellurics directed towards propagation detection and communication phenomena.
Recording Site	Signal Component	Basic Instrument	Bandwidth	Full Scale Sensitivity	Timing Accuracy	Recording Status and % Time
Culver City	ਸ <sub>×</sub> ਲ <sub>&gt;</sub>	lead electrodes	0-100 kc "	0.7-40 mv/km "	. 01 sec	Capable of 100%
Notes and References: A report is available.	ailable.				·	- a · · · · · · · · · · · · · · · · · ·

Research Group: Jersey Productio Tulsa, Oklahoma	Research Group: Jersey Production Research Co. Tulsa, Oklahoma	Report F. G.	ed by: Boucher	Special Interests: Relationship between magnetotellurics and other phenomena	ests: oetween magr nomena	netotellurics
Recording Site	Signal Component	Basic Instrument	Bandwidth	Full Scale Sensitivity	Timing Accuracy	Recording Status and % Time
Leonard, Okla.	H	Meta stable Helium Mag.	0.01-1cps	1 γ	•	%001
	д <sup>ж</sup> д д	Magnetometer	Long period	2.7 y/mm	2 sec *	100%
	E X E Y E Variations	Potential spreads x and y 1000' z 0-1200'-2400'	dc - 1 cps	x & y 20 mv z 10 mv		100%
:	electron density in ionosphere	Riometer				
Notes and References: * Accuracy of picking	ferences:	Notes and References: * Accuracy of picking events based on chart speeds used.	eeds used.			

Research Group: Lamont Geological Observatory Torrey Cliff Palisades, New York	cal Observat York	Reported by:  J. Heirtzler	by:	Special Interests: 1 - 1000 sec perio variations.	Special Interests: 1 - 1000 sec periods and their spectral variations.	eir spectral
Recording Site	Signal Component	Basic Instrument	Bandwidth	Full Scale Sensitivity	. Timing Accuracy	Recording Status and % Time
Lebanon State Forest, N.J.	H	R, Mag- netometer	0 - 1 cps	2y or 6y	±0.1,sec/day ±0.01 sec/hr	greater than 50%
Ocean bottom	н³	Proton precession magnetometer	0-0.05 cps	300х		100%
Lebanon State Forest, N.J.	н <sup>х</sup> т <sup>х</sup>	Cored coils				future
Notes and References:	 					•

Research Group: Lockheed Aircraft Physical Sciences Lab. Palo Alto, Cal.	ıp: :raff ices Lab.  .	Reported by: Lee R. Tepley	b <u>y:</u> apley	Special Interests: Pearls	ests:	
Recording Site	Signal Component	Basic Instrument	Bandwidth	Full Scale Sensitivity	Timing Accuracy	Recording Status and % Time
Palo Alto, Cal.	H, H, E	Proton Mag. 0-1/60 cps Air Core Loop 0.3-7 cps Vertical Antenna 5-50 cps	0-1/60 cps 0.3-7 cps 5-50 cps	100 γ 0.0003 γ* 50 μv/m*	0.1 sec	100% since Feb 61 through 63.
Hawaii, Tonga-Tapu (Tonga Islands)	T H H	Iron Core Loop  Earth Current	0.3-7 cps 0.3-50 cps	0.001 y* 20 µv/km *	0.1 sec	May-Aug, 62, 100% Sept 62 - Jan 63 100%
Canton Island	д <sup>ж</sup> д <sup>х</sup>	Iron Core Loop	0.3-7 cps 0.3-7 cps	0.001 y* 0.001 y*	0.1 sec	Sept 63 to present 100%
Notes and References:  * Instrument Noise Instructure and Attachment	ss and References: Instrument Noise Levels	s and References: Instrument Noise Levels "Structure and Attenuation of Hydromagnetic Emissions." Vol. I and II. Lee R. Tepley and	ic Emissions.	"Vol. I and II.	Lee R. Tepl	ev and

peructure and Attenuation of Hydromagnetic Emissions, vol. 1 and 11, Lee K. Tepley and R. C. Wentworth, Lockheed Missiles and Space Co., Scientific Report No. 1, 6 April 1962.

Research Group:	:dn	Reported by:		Special Interests:		
Massachusetts Institute Technology Cambridge, Massachus	s Institute of fassachusetts	T. Cantwell T. Madden	. and	Magnetotellurics, pearls, Schumann resonances, and other interesting geomagnetic phenomena.	, pearls, Sc other intere iomena.	humann sting
Recording Site	Signal Component	Basic Instrument	Bandwidth	Full Scale Sensitivity	Timing Accuracy	Recording Status and % Time
Mobile sites in Mass., N.H., Maine	ы х у х у	Horizontal grounded antenna µ metal coils	0.005-2 cps and 0.05-50 cps	5 my/cps		Mobile station only at present time.
Fixed Site to be set up 20 miles west of Boston	ਜ <sub>×</sub> ਜ <sub>≻</sub>					and the same of th
						an an ing ngangan an a
						A PARTIES AND THE PARTIES AND
Notes and References: T. Cantwell PhD Thesis and letter in J. G. R.	ices: Thesis and lette	r in J. G. R.				ent artis i ene majore ma

.

•

Research Group:	ä	Reported by:	d by:	Special I	Special Interests:	
National Aeronautical Establishment Ottawa, Canada	autical :	Murray Strome	Strome	Airborne of magnet	Airborne magnetometers - Noise power of magnetic background 0.05-1.0 cps	- Noise power .05-1.0 cps
Recording Site	Signal Component	Basic Instrument	Bandwidth	Full Scale Sensitivity	Timing Accuracy	Recording Status and % Time
1) Peat bog	H	Coi1	0.05-0.5 cps	٥.7 ۲	±0.2 sec	%001
2) Uplands air- port <sup>1</sup>	H	Magnetometer	0-1.0 cps	2.0γ	=	As planned
3)Airborne	н		=	=	" (.02 sec with special precautions)	=
Notes and References	9					

Notes and References:  $1 0.2 \gamma$  background reduces usefulness.

Research Group: National Aeronautics and Space Administration Ames Research Center Moffett Field, California	p: autics and stration h Center California	Reported by: Darrell D. M	by: O. McKibbin	Reported by: Special Interests: Darrell D. McKibbin Earth-Solar Magnetic Fields	sts: fagnetic Field	· ·
Recording Site	Signal Component	Basic Instrument	Bandwidth	Full Scale Sensitivity	Timing Accuracy	Recording Status and % Time
	H <sup>1</sup>	Stationary Search Coils				
		Fluxgate	0-50 cps	1 - 100 γ		
		He-Magnetom- eter				
				а <del>при</del> водителниция с объекто останова		
		i		ana ann an Aireann		
	uariandau-tall'ar 1924, per <sup>a</sup> 1924			•		•
Notes and References:	es:					
	·					

.

.

Research Group: Naval Ordnance Lab.	: Lab.	Reported by: C. R. Larkin	y: kin	Special Interests: Background at sea	ests: at sea		
Silver Spring, Md.	ſd.						
Recording Site	Signa1 Component	Basic Instrument	Bandwidth	Full Scale Sensitivity	Timing Accuracy	Recording Status and % Time	· ·
White Oak Silver Spring, Maryland	ਸ਼ ਸ਼	Helium Mag. Rb. Mag.	0.01-10 cps	2, 6.7, 20γ	Not specified Tuning	No definite schedule. Some measurements on sea bottom	
and sea bottom	, H <sub>X</sub>	Coils	to 1 cps		fork and xtal ref-		
	нун <sub>z</sub>	= <b>=</b>	= =				*
							.,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,
				i			
Notes and References:	ences:						

Naval Ordnance Laboratory Technical Report 61-7

Research Group: Advanced Systems Analysis Space and Information Systems Div. North American Aviation, Inc. Downey, California	is Analysis nation Systems I Aviation, Inc. nia	R. A. Fowler Div.	·	Special Interests: Magneto-tellurics firing as well as faction.	s: cs from nucle s from solar	Magneto-tellurics from nuclear blast and missile firing as well as from solar terrestrial interaction.
Recording Site	Signal Component	Basic Instrument	Bandwidth	Full Scale Sensitivity	Timing Accuracy	Recording Status and % Time
Santa Susana Mountains Chatsworth, California	ы Х Б	1000 ft. apart ground probes	0-40 cps 30 cps- 30 Kc 100 cps- 1 Kc 200 cps- 2.5 Kc	.4-500 wicro volts meter	l millsec.	Only during nuclear tests.
	H H Y Z	air core loop	0-40 cps 30 cps- 30 Kc 100 cps- 1 Kc 200 cps- 2.5 Kc	0.001 γ *0:001 γ 0.001 γ		
Notes and References: Magneto-Teleric Data North American Aviati	Notes and References: Magneto-Teleric Data Collect North American Aviation Inc.	Notes and References: Magneto-Teleric Data Collection and Data Handling Capabilities North American Aviation Inc.	ndling Capabil:	lties		

Research Group:		Reported by:	d by:	Special Interests:	erests:	
<b>Pac</b> ific Naval Laboratory Victoria, B. C.	boratory	J. A. Si	Shand	Relationsh effects, di pulsation a	Relationship with ionosphere, conjug effects, directional effects of micropulsation and ELF, latitude effects.	Relationship with ionosphere, conjugate effects, directional effects of micropulsation and ELF, latitude effects.
Recording Site	Signal Component	Basic Instrument	Bandwidth	Full Scale Sensitivity	Timing	Recording Status and % Time
Westham Island, B. C. <sup>1</sup> (near Vancouver)	H Y H Z	Coil "	0.003-3 cps	Noise level <0.01y peakto peak at 1 cps	Radio signals on tape Accuracy not specified	Experimental
St. Hilaire, P. Q <sup>2</sup> (near Montreal)	1	11	Also 2-40 cps	Depends on station	=	Experimental Specified schedules
Byrd Station, Antarctica Great Whale River, P. Q.	нин Х	Coil " " Rb. Mag.	Approx. 0, 1 cps near selected frequencies	Noise level <0.0001 y 80 v. 200 v	z :	6"/hr most of time - higher speed on certain schedules. Tape used on schedule.
Raiston, Alberta	44			•		Future
Notes and References:  1 Operated by University of Britis 2 Operated by McGill University 3 Operated by Stanford University 4 Type of measurements at each languages.	iversity of Brit Gill University nford Universit ements at each	itish Columbia y ity h location appe	Operated by University of British Columbia Operated by McGill University Operated by Stanford University Type of measurements at each location appear to be flexible to a certain extent.	e to a certain ex	tent.	

Research Group: University of Puerto Rico Mayaguez, P.R.	Puerto Rico	Reported by: Prof. Braul	Reported by: Prof. Braulio Dueno	Special Interests: Relationship between geomagnetic mic pulsations and ionosphere, radio-star ionospheric drift experiment.	ests: between geom:   ionosphere, rift experimen	Special Interests: Relationship between geomagnetic micropulsations and ionosphere, radio-star ionospheric drift experiment.
Recording Site	Signal Component	Basic Instrument	Bandwidth	Full Scale Sensitivity	Timing Accuracy	Recording Status and % Time
Mayaguez, P.R.	<b>н</b> .	Rb. Vapor Magnetometer	3 kc	20γ	6 in/hr 6 in/min	100%
						ı
Notes and References: *Chart speeds	ferences:		,			

Research Group: Dept. of Electrical Engine University of Rhode Island Kingston, R. I.	p: ical Engineering hode Island	Reported by:	<u>ьу:</u>	Special Interests: Schumann resonar	onances and	Special Interests: Schumann resonances and related phenomena.
Recording Site	Signal Component	Basic Instrument	Bandwidth	Full Scale Sensitivity	Timing Accuracy	Recording Status and % Time
Kingston, R. I.  lat. 41°29'45"  Long. 71°31'37"	ж н А	Iron Core Coils*	50-20 cps	2 x 10 <sup>-5</sup> amp/m Ordinary mechanic clock clock to sec Checked by NBA	Ordinary mechanical clock 1 sec Checked by NBA	Sample one minute every ten minutes 24 hrs/day
Notes and References:  * Extremely low frequency C. Polk and F. Fitchen, Journal of Research of the	rences: w frequency rece r, Fitchen, Sciel search of the NI	reception at Kingston, Rhode Island Scientific Report No. 1 1e NBS, Vol. 66D, No. 3, May-June	on, Rh <b>o</b> de Isla o. 1 No. 3, May-J	Extremely low frequency reception at Kingston, Rhode Island C. Polk and F. Fitchen, Scientific Report No. 1 Journal of Research of the NBS, Vol. 66 D, No. 3, May-June 1962, p. 313-318	-318	

	Research Group: Apparatus Division Texas Instruments, Inc.	Reported by: Arthur W. G	Reported by: Arthur W. Green, Jr.	Special Interests: Magnetotelluric m spectra and freq	ests: ric micropu	Special Interests: Magnetotelluric micropulsation power spectra and frequency of occurrence
6000 Lemmon Avenue Dallas, Texas				data from (	data from 0.01 to 20 cps.	<b>8</b> ,
Signal Component		Basic Instrument	Bandwidth	Full Scale Sensitivity	Timing Accuracy	Recording Status and % Time
H t ma	ma	Metastable helium magnetometer	0.01-2.0 cps	0.25, 0.5 1, 5y		
n <sub>x</sub> n <sub>y</sub>			0.01-2.0 cps	0.8 mv/km and 8 mv/km	0.1 sec	10%
π <sup>×</sup>		Permeable core probes	1 - 2 cps			future
H v		=	=			
					Λ	
Green, A. W., Jr. and List, B.	ų.	· H., "The Th	eory Measurem	ent and Applica	ations of ver	List. B. H. "The Theory Measurement and Applications of Very Low Frequency

Green, A. W., Jr. and List, B. H., "The Theory Measurement and Applications of Magnetotelluric Variations," Proc. I.R.E., Nov. 1962.

Research Group:		Reported by:	by:	Special Interests:	sts:	
Electrical Engineering Research Laboratory The University of Texas Austin, Texas	neering Rese of Texas	н. w. F. X.	Smith Bostick	Magnetotellurics, signals over larg		coherence of component e distances.
Recording Site	Signal Component	Basic Instrument	Bandwidth	Full Scale Sensitivity	Timing Accuracy	Recording Status and % Time
Austin, Texas Fixed station	н×н	Air Core Coils	0:002-2 cps	1 4		,
	дан <sub>х</sub> н	Ground probes	0.005-2 cps	l mv/km	.01 sec	100%
Mobile station	× H	Iron Core	0.002-10 cps	1γ		Variable at
	, H <sub>z</sub> H <sub>x</sub> H	Coils Ground Probes	0.005-10 cps	250 µv/km	.01 sec	different sites
Past Mobile Sites Grand Bahama Is.	Oct. 1961	- Jan. 1962				
Puerto Rico	June	- Oct. 1962				
Notes and References: EERL Report Nos. 111,	11,	112, 113, 115, 116, 118, 119, 120, 123, 126, 127, 128	119, 120, 123, 1	26, 127, 128		
J.G.R. March 1961	1961					
			,			

Research Group: U.S. Coast and Geodetic Washington, D.C.	eodetic	Reported by: Survey L. R. Alldre	Reported by: L. R. Alldredge	Special Interests: General interest in all ph short period fluctuations.	est in all pha fluctuations.	Special Interests: General interest in all phases including short period fluctuations.
Recording	Signal Component	Basic Instrument	Bandwidth	Full Scale Sensitivity	Timing Accuracy	Recording Status and % Time
Fredericksburg, Va. Tucson, Ariz. Barrow, Alaska College, Alaska Sitka, Alaska Honolulu Guam Byrd Sta., Antarc. Eights Sta., "	# H H Z	Magnetograph using suspended or balanced permanent magnets	dc - 0.2 cps dc - 0.2 cps dc - 0.1 cps	2 to 5 gammas/mm of ordinate	*	at all except Eights Station, Antarctic which is currently being installed.
Notes and References:  Conventional geomagnetic terminology  Sufficient and consistent with chart sp	geomagnetic consistent w	es and References: Conventional geomagnetic terminology Sufficient and consistent with chart speeds				

						cont'd on next page
Research Group:	×	Reported by:	::I	Special Interests:	erests:	
U.S. Geological Survey Theoretical Geophysics Branch Denver, Colorado	l Survey ophysics Bra do	George V. Keller ınch	Keller	Magnetotel resistivity	Magnetotelluric Field - resistivity determination	
Recording Site	Signa1 Component	Basic Instrument	Bandwidth	Full Scale Sensitivity	Timing Accuracy	Recording Status and % Time
Bergen Park Observatory (35 miles west of Denver, Colo	H H H A A A A	Earth probes " Helium-Vap. Mag. Air Core Coils " "	Not Specified	Not Specified	Crystal- controlled electronic clock - WWV to 10 m sec at best	Crystal- Schedule not given. controlled Recording on May tape electronic at 0.3 ips and 4 channel clock - WWV visual monitor at chart to 10 m sec speed 1 cm/min at best
Hawaiian Volcano Obs. (30 miles S. of Hilo, Hawaii)	E <sub>X</sub>	Earth probes " " Air core coil	Not Specified	Not Specified	Mechanical chronometer ref - WWV once daily	Schedule not given.  Normal recording-4- channel charts at 1.5 cm/min. Speeds to 600 cm/min.
Mobile Magneto telluric Obs.	֟ヹ゚ヸ <sup>™</sup> ヸヹ゚゚゚゚ <sup>™</sup>	Earth probes  " RbVap. Mag " " " Air core coil	Not Specified	Not Specified	xtal-cont. WWV-Rec.	Schedule not given. Recording on mag tape at 0.3 ips and 4-channel recorder - 1.5 cm/min to 600 cm/min chart speeds

## Notes and References:

- Effective area 64,000 sq. meters
- $25 \times 10^6$  sq. meter coil to be added before end of 1962
- Magnetometer modified to record total field or a component or components sequentially
  - Effective Area 52,000 sq. meters

	Kecording Status and % Time Schedule not given. Recording on 4-channel recorder with speeds 1.5 cm/min to 600 cm/min Also 7-channel recorder with speeds 3.6 cm/min to 3600 cm/min.		
rests:	Timing Accuracy xtal-cont. WWV-Rec.		
Special Interests:	Full Scale Sensitivity Not specified		
7: Keller	Bandwidth Not specified		
Reported by: George V. Keller	Earth probes  Air core coils  " " " " "		. meters
p:	Signal Component E E H <sup>y</sup> 5 H <sup>y</sup> 5 H <sup>y</sup> 6 Z	: .	es and References: Effective area - 64,000 sq. Effective area - 52,000 sq.
Research Group: U. S. Geological Survey (cont'd)	Mobile Earth Current Systems (3 systems)		Notes and References: 5. Effective area - 64,000 6. Effective area - 52,000

sations o		future	
nicropule elative to nent.	Status	present,	
c storms, m ent effects r ction equipm	Recording Status and % Time	75% past, present, future 75% "	
Special Interests: Observation of magnetic storms, micropulsations and related earth current effects relative to magnetic anomaly detection equipment.	Timing Accuracy	at 6"/hr ±15 sec at 2"/min ±1 sec. Future "	
Special Interests: Observation of mand related earth	Full Scale Sensitivity	70 Y 6. 7 Y*	
∺ se	Bandwidth	1 reading/min 0 - 1/4 cps 0.07 - 0.7 cps	
Reported by: D. P. Miles	Basic Instrument	Proton Prec. Mag. Rb. Vap. Mag. Rb. Vap. Mag. Coils	
)evelopment	Signal Component	т т т т и х м м м м м м м м м м м м м м м м м м	
Research Group: U. S. Naval Air Development Center Johnsville, Pa.	Recording Site	U. S. Naval Air Dev. Cent. Johnsville, Pa. Lat. 40°12'N. Long. 75°04'W.	

## Notes and References:

Recording on paper charts with mag. tape to be installed. U.S. Naval Air Development Center Reports No. NADC-AW-6226 and 6249. \* 2 y full scale during special events

				ď		
Mashington 25, D. C.	Research Group: U. S. Naval Oceanographic Office Marine Sciences Department Washington 25, D. C.		R. H. Randall, Jr.		מורפונים דוורפונים מורפונים מו	. <b>1</b>
Recording Site	Signal Component	Basic Instrument	Bandwidth	Full Scale Sensitivity	Timing Accuracy	Recording Status and %Time
Wallops Is., Virginia						Not yet operational
Notes and References:	rences:					

٠.

Research Group: Instrument Division Varian Associates 611 Hansen Way Palo Alto, Calif.	p: ision ites if.	Reported by: Breiner	d by:	Special Interests: Providing magnetometers to record at all frequencies. Gradiometer configurations cancelling out micropulsation activity ove distance of a few feet to a few miles.	sts: inetometers to Gradiometer of micropulsatio ew feet to a fe	Special Interests: Providing magnetometers to record at all frequencies. Gradiometer configurations, cancelling out micropulsation activity over distance of a few feet to a few miles.
Recording Site	Signal Component	Basic Instrument	Bandwidth	Full Scale Sensitivity	Timing Accuracy	Recording Status and % Time
Site 501 Stanford Univer sity Varian Associates Palo Alto, Cal	<b>#</b>	R, Vapor magnetometer	0.001-3 cps	20γ	+1 sec	%08
Notes and References: Varian Associates Ru X-4936 Data Sheet	rences: ttes Rubidium neet	es: Rubidium Vapor Station Magnetometer	lagnetometer			

Reported By: Special Interests:	Accurate timing of magnetohydrodynamic phenomena.  Statistical processing of geomagnetic data obtained under rigidly controlled conditions (i.e. stable and well defined sensitivity, wide-band linear frequency response etc.)	Basic Bandwidth Full Scale Timing Recording Status Instrument Sensitivity Accuracy and % time	Three com- 0.1-1 cps 10 $\gamma$ , 20 $\gamma$ Slow Declination-intermittent recording gate. $^{2}_{4}$ (Saturable core)  Modified for in- creased sensitivity $^{2}_{7}$ (Saturable core)  Saturable 10 $\gamma$ , 20 $\gamma$ hour mark horizontal and H not recording recording recording $^{2}_{2}$ 10 $\gamma$ , 20 $\gamma$ recording $^{2}_{2}$ 10 $\gamma$ , 20 $\gamma$ recording remains and H not operational until $^{2}_{7}$ 963	and References: eference 1. Caner and Whitham, Can. J. Physics, 1962, Vol. 40 No. 12
Reported By:	B. Caner		flux- flux- ble ed a vity	Physics, 1962.
:dnc	Victoria Magnetic Observatory Royal Oak, B.C., Canada	Signal Component Ins	Magnetic Field The Declination gas Horizontal (S)	ences:
Research Group:	Victoria Mag Royal Oak, E	Recording Site	Victoria Magnetic Observatory Geographic Coordinates 48°31°N - 123°35'W	Notes and References *Reference 1. Caner and W

Research Group: Department of Geophysics Weston Observatory Weston 93, Mass.	<u>p:</u> Geophysics atory ss.	Reported by: Daniel Linehan,	by: nehan, S. J.	Special Interests: Absolute calibrati	ests: ibration of n	Special Interests: Absolute calibration of magnetic instruments
Recording Site	Signal Component	Basic Instrument	Bandwidth	Full Scale Sensitivity	Timing Accuracy	Recording Status and % Time
	<sup>1</sup> H	R <sub>b</sub> Vapor magnetometer	0-0.2 cps	20 γ		
Weston Observatory, Weston	щ°	Proton precession sion magnetometer	0 - 0.02 cps	2000 y		100%
	HH	Ξ	Ξ	2000 γ		
	Declination	Ξ	=	2000 γ	,	
	ы×		0 - 1 cps	100 mv/500 ft		
	<b>a</b> ≻		=	200 mv/2K ft		100% experi-
	ក្		Ξ	100 mv/500 ft		1831011
Notes and References: Transactions of AGU, Sept. 1961. Weston Magnetic Facility, R. O.	rences: f AGU, Sept. l ic Facility, R.	Hut chinson,	J. Pomeroy, S.J.	S. J.		

## DISTRIBUTION LIST

Addressee	Attention	No. of copies
ASTIA Arlington Hall Station Arlington 12, Virginia	TIP-Dr	10
Director of Defense Research & Development The Pentagon Washington 25, D.C.	Technical Library Room 3C-128	<b>ì</b> .
Office of the Chief Signal Officer Department of the Army Washington 25, D.C.	SIGFO-64	1
Engineering & Technical Division Office of the Chief Signal Officer Department of the Army Washington 25, D.C.	SIGET	1
Director of Research U. S. Army Signal Research & Development Laboratories Fort Monmouth, New Jersey		3
Commanding Officer U. S. Army Signal Research & Development Laboratories Fort Monmouth, New Jersey	N. Abbott	1
Administrative Engineer Signal Corps Engineering Laboratory Fort Monmouth, New Jersey		1
Chief of Naval Research Department of the Navy Washington 25, D.C.	Code 427 Code 416	2 1
Director U. S. Naval Research Laboratory Washington 25, D. C.	Code 2000 Code 2027 Code 1360	6 2 1
Chief, Bureau of Ships Department of the U.S. Navy Washington 25, D.C.	Code 337 Code 686	2 2
Chief, Bureau of Aeronautics Department of the U.S. Navy Washington 25, D.C.,	EL 50 EL 90	1 .
Department of the Navy ONR, Boston Branch Office 495 Summer St. Boston 10, Massachusetts		1

Dist. List - p. 2 Nonr 375(14)

Bureau of Naval Weapons Department of the U.S. Navy Washington 25, D.C.	RRE-3	1
Chief of Naval Operations Frequency Allocation Sect. OP-941Q Room 5E777, The Pentagon Building Washington 25, D. C.		1
Chief of Naval Operations Department of the U.S. Navy Washington 25, D.C.	Op 413	1
Director, ONR Branch Office 346 Broadway New York 13, N.Y.		1
Director, ONR Branch Office The John Crerar Library Building 10th floor 86 E. Randolph St. Chicago 1, Illinois		1
Chief Scientist ONR Branch Office 1030 Green Street (East) Pasadena 1, California		. 1
Officer in Charge, ONR Navy No. 100 - Fleet Post Office New York, N.Y.		1
Commanding Officer U.S. Naval Underwater Sound Labora New London, Connecticut	tory	1
Commanding Officer Naval Air Development Center Johnsville, Pennsylvania	AAEL	1
Director Naval Ordnance Laboratory White Oak, Maryland		1
Commander U.S. Naval Ordnance Test Station China Lake, California	Technical Library Code 753	1
Librarian, U.S. Naval Postgraduate School Monterey, California		1
U.S. Naval Electronics Laboratory San Diego 52, California	Library	1

Dist. List - p. 3 Nonr 375(14)

Alderman Library University of Virginia Charlottesville, Virginia	John C. Wylie	1
Commanding General Hq., USAF Washington 25, D.C.	AC-AS/4:AFDRE	1
Aeronautical Systems Division Deputy for Technology-Avionics Div. Electromagnetic Warfare & Commications Electromagnetic Environment Branch Propagation Section Wright-Patterson AFB, Ohio	Paul W. Springer ASRNCF-2	1
AF Cambridge Research Laboratories Electronics Research Directorate Office of Aerospace Research L. G. Hanscom Field Bedford, Massachusetts	CRRK CRRI CRRD CRRS	1 1 1
AF Cambridge Research Laboratories Geophysics Research Directorate Office of Aerospace Research L. G. Hanscom Field Bedford, Massachusetts		1
Commander AF Office of Scientific Research Washington, D.C.	Dr. Wm. J. Otting, Jr.	1
U.S. Weather Bureau Department of Commerce Washington, D.C.	Director Radar Engineering	1
Boulder Laboratories National Bureau of Standards Boulder, Colorado	Library W. H. Campbell Ionospheric Res. & Propagation Div.	1
Office of Technical Services U. S. Department of Commerce Washington 25, D. C.		1
ITT Laboratories 3700 E. Pontiac Street Fort Wayne, Indiana	Mrs. Ann Bley	1
Maurice W. Long Engineering Experiment Station Georgia Institute of Technology Atlanta 13, Georgia		1

Dist. List - p. 4 Nonr 375(14)

Department of EE University of Michigan Ann Arbor, Michigan	Dr. S. S. Atwood	1
Research Laboratory of Electronics M. I. T. Cambridge, Massachusetts	H. Zimmerman	1
Federal Communications Commission Room 2209, New P.O. Bldg. Washington 25, D.C.	Asst. Chief Engineer in charge of Technical Research Division	1
Stanford Electronics Laboratories Stanford University Stanford, California	Applied Electronics Lab Document Library	1
Library, ERL 427 Corey Hall, Univ. of California Berkeley 4, California	Miss L. Khouri	1
Documents Library R-3446 General Electric Company Missile and Space Vehicle Dept. 3198 Chestnut Street Philadelphia 4, Pa.	Lawrence I. Chasen Mgr., Library	1
Bell Telephone Company P.O. Box 107 Red Bank, New Jersey	Dr. R. Kompfner	1
Dr. William A. Miller Senior Staff Scientist Electronics Systems Division Fairchild Stratas Corp. Straight Path Wyandanch, N. Y.		1
Electrical Engineering Res. Labs. University of Illinois Urbana, Illinois	P. D. Coleman	1
RCA Laboratories Princeton, New Jersey	Miss Fern Cloak	1
Technical Reports Collection Gordon McKay Library Harvard University Div. of Eng'g. and Appl. Physics Pierce Hall, Oxford Street Cambridge 38, Massachusetts	Mrs. Elizabeth Farkas	ì
School of Electrical Engineering Cornell University Ithaca, New York	Dr. W. E. Gordon	1

Dist. List - p. 5 Nonr 375(14)

Commandant (EEE) U. S. Coast Guard (Sta 5-5) 1300 E Street, N. W. Washington 25, D. C.		1
M. I. T., Lincoln Laboratory Box 73 Lexington 73, Massachusetts	Dr. James H. Chisholm	1
Dept. of Electrical Engineering California Institute of Technology Pasadena, California	Dr. C. H. Papas	1
Applied Physics Laboratory The Johns Hopkins University 8621 Georgia Avenue Silver Spring, Maryland	Geo. L. Seielstad	2
New York University Institute of Mathematical Sciences 25 Waverly Place New York 3, N.Y.	Prof. Morris Kline	1
Program Director, Eng'g. Sciences National Science Foundation Washington 25, D.C.		ł
Antenna Research Laboratory Ohio State University Columbus 10, Ohio	Dr. Thomas Tice	1
Tektronix, Inc. P.O. Box 500 Beaverton, Oregon	Library	1
Smyth Research Associates 3555 Aero Court San Diego 11, California	Electronics Branch	1
Cornell Aeronautical Laboratory, Inc. 4455 Genessee Street Buffalo 21, New York	John P. Desmond, Librarian	1
New York University College of Engineering Dept. of Meteorology & Oceanography University Heights New York 53, N.Y.	Prof. W. J. Pierson	1
Dr. Nicholas George 333 Spalding Building California Institute of Technology Pasadena, California		1

Dist. List - p. 6 Nonr 375(14)

Texas A & M College College Station, Texas	Dr. Vance Moyer, Radar Met. Section	3
Sylvania Electric Products, Inc. P.O. Box 205 Mountain View, California	Miss Katherine Johnson Electronics Defense Lab.	1
Radio Research Laboratories Ministry of Post & Telecommunications Kokubunji Post Office Tokyo, Japan VIA: U.S. Naval Attache for Air Tokyo, Japan	Planning Section	1
Harvard Observatory 60 Gärden Street Cambridge 38, Massachusetts	A. E. Lilley Dept. of Radio Astronomy	1
University of Arizona Tucson, Arizona	Mr. George Savage Inst. of Atmos. Physics	1
Technical Research Group, Inc.  2 Aerial Way Syosset, New York	Jerome R. Lurye	1
Loral Electronics Corporation 835 Bronx River Avenue New York 72, N.Y.	W. Honig	
National Bureau of Standards P.O. Box 299 Boulder, Colorado	Mr. M. C. Thompson	1
Research Laboratory of Electronics Chalmers Institute of Technology Gothenburg, Sweden	Christina Walsh	1
Advanced Research Projects Agency Room 3D 170, The Pentagon Washington 25, D.C.	Lt. Cmdr. D. E. Chandler	1
Alan H. Barrett, Assoc. Prof. Room 26-49 M.I.T. Cambridge 39, Massachusetts		1
Hughes Aircraft Company Communications Division Box 90902 Los Angeles, California		1

Dist. List - p. 7 Nonr 375(14)		
Dr. C. I. Beard Boeing Scientific Research Labs. P. O. Box 3981 Seattle 24, Washington		1
Mr. Charles R. Burrows Senior Scientist Radio Eng'g. Labs., Inc. 4925th Street, Elmo Ave. Bethesda 14, Maryland		1
University of Chicago Laboratories for Applied Sciences Museum of Science & Industry Chicago 37, Illinois		1
Instituto Geofisico del Peru Apartado 3747 Lima, Peru	Dr. Robert Cohen	1
Jet Propulsion Laboratory California Institute of Technology 4800 Oak Grove Drive Pasadena, California	I. E. Newlan Technical Reports Section	1
Manila Observatory Ateneo De Manila University P.O. Box 1231 Manila, P.I.		]
Geophysical and Polar Research Center University of Wisconsin 6021 South Highland Road The Highlands Madison 5, Wisconsin	Mr. Forrest L. Dowling	1
Director U. S. Army Engineer Research and Development Laboratories Fort Belvoir, Virginia	Technical Documents Center	1
U.S. Army Materiel Command Harry Diamond Laboratories Room 211, Building 92 Washington 25, D. C.	Mrs. A. Porter	